gives an insight into the way in which he gained his intimate knowledge of the strata of the country. "The whole of the remainder of 1821 was devoted to long and laborious wanderings. Two lines of operation were drawn through the country which required to be surveyed. On one of these Mr. Smith moved with the due deliberation of a commander-in-chief; the other was traversed by his more active subaltern, who afterwards found the means to cross from his own parallel to report progress at head-quarters." In this way 2,000 miles were traversed in six months, and he thus learned to rely on his own judgment. His work delighted him. "Innumerable rambles," he says, "led up every glen and across every hill, now sketching waterfalls, anon tracing the boundaries of rocks or marking the direction of diluvial detritus." As greater accuracy in tracing the boundary of different strata was thus acquired, the successive issues of the map of England were modified. The lines of these alterations were mostly traced by Mr. Phillips himself, and thus it was that differences appeared in maps which apparently belonged to the same "edition."

At length, in 1824, Mr. Smith was asked to deliver a course of lectures on his geological work at the newly-formed Yorkshire Philosophical Society. For this "new maps were coloured, new sections drawn, and even the distant cabinet of Mr. Richardson at Farley was laid under contribution, to supply illustrations for these discourses." Lectures at Hull, Scarborough, and Sheffield soon followed. The share that Mr. Phillips took in the preparation of these lectures brought him under the notice of the executive of the Yorkshire Philosophical Society; he was offered the curatorship of the new museum, and accepted it. This was one of the important events of his life. His work no longer came before the public in his uncle's name, he had an individuality of his own, "and commenced to make his own reputation." I was delighted to find in the prosecution of this duty innumerable proofs of the truth of Mr. Smith's views respecting the distribution of organic fossils, and saw very clearly that many of the strata in the north-eastern part of Yorkshire might be confidently identified with well-known formations in the south of England. Soon after (in 1826) he read before the Society the first paper he wrote. His subject was: The Direction of the Diluvial Currents of Yorkshire, and it was thought worthy of being reprinted in the "Philosophical Magazine." From this time his pen was ever active. His early geological papers were on Yorkshire, and with that county his name is indissolubly connected. In addition to the curatorship of the museum he was appointed one of the secretaries of the Society, and delivered courses of lectures, and in 1829 he published his illustrations of the Geology of Yorkshire.

It was not till 1834 that Mr. Phillips communicated a paper to the Geological Society, and in the same year he published his "Guide to Geology," was appointed Professor of Geology in King's College, London, and was elected a Fellow of the Royal Society. His recommendature to election into the Society is of sufficient interest to be printed, and is as follows:—

"John Phillips, Esq., of York, Fellow of the Geological Society of London and Secretary of the Yorkshire Philosophical Society, a gentleman well versed in geology, meteorology, and various branches of natural science, and author of "Illustrations of the Geology of Yorkshire," being desirous of becoming a Fellow of the Royal Society, we whose names are hereunto subscribed do, from our personal knowledge, recommend him, as highly deserving of the honour he solicits, and likely to prove a valuable and useful member.

"Rod. I. Murchison, Wm. Buckland, G. B. Gresnough, William Clift, Edw. Turner, Adam Sedgwick, John Taylor, H. T. De la Beche, C. Daubeny, John Edw. Gray, Geo. Peacock, John Lindley, B. Powell.

"Elected April 10, 1834."

Not only was he associated in work with the "father" of Geological Science, from which such valuable practical results have flowed, but he was one of the band who, in his own words, "stood anxious but hopeful by the cradle of the British Association." It is well known how through his activity the first meeting at York was a success in September 1831, and how till 1863 he was the courteous assistant-secretary of the Society.

Among other posts Prof. Phillips has filled are the Chair of Geology at Dublin, to which he was appointed in 1844; the Presidency of the Geological Society in 1859-60; Rede Lecturer in Cambridge in 1860; and the Presidency of the British Association in 1866. The Chair at Oxford he has held since 1853.

He not only helped to lay the foundations of English Geology, he has been to the last an active worker and an industrious writer. Besides more than sixty papers communicated to Societies' proceedings and to magazines, he was largely a contributor to the "Penny Encyclopædia," the "Encyclopædia Britannica," and the "Encyclopædia Metropolitana."

In 1841 was published his "Palæozoic Fossils of Cornwall, Devon, and West Somerset, after he had examined the country in company with Mr. William Sandars.

In 1842 he began an examination of the Malvern district, and having settled his data at Malvern, Abberley, and Woolhope, he extended his observations to May Hill, Fortworth, and Usk. The work was given to the world in 1848 as one of the Memoirs of the Geological Survey. "The Rivers, Mountains, and Sea-coast of Yorkshire" appeared in 1853, and his Essay in the "Oxford Essays," in 1855.

His contribution to the Palæontographical Society on the Belemnitidæ, and his "Geology of the Thames Valley," are well known; and he has also written many smaller works which we have not space to notice.

For many years he has been Keeper of the Museum at Oxford, and his lectures have had such a reputation for being popular that they have been largely attended by ladies. The Professor had also given much time to meteorology and astronomy, and had made many observations in his own observatory. He was an honorary M.A. and D.C.L. of Oxford, and LL.D. of Cambridge and Dublin.

NOTES

Dr. Lyon Playfair, C.B., has given notice that, on the House of Commons going into committee on the Education Estimates, he will call attention to the deficient ministerial responsibility under which the Votes for Education, Science, and Art are administered, and will move for a Select Committee to consider how such ministerial responsibility may be better secured. We believe that Dr. Lyon Playfair's views are strictly in accordance with those of the best scientific men of the country, namely, that the only satisfactory way of dealing with the subject will be by the appointment of a Minister for Education, Science, and Art.

The 15th or 16th of June has been fixed for the inauguration of the physical laboratory, the gift of the Duke of Devonshire to the University of Cambridge.

The following is a list of candidates selected and recommended by the Council of the Royal Society for election as Fellows:—Isaac Lowthian Bell, F.C.S.; W. T. Blanford, F.G.S.; Henry Bowman Brady, F.L.S.; Dr. Thomas Lauder Brunton, Sc.D.; Prof. W. Kingdon Clifford, M.A.; Augustus Wollaston Franks, MA.; Prof. Olaus Henrici, Ph.D.; Prescott G. Hewett, F.R.C.S.; John Eliot Howard, F.L.S.; Sir Henry Sumner Maine, LL.D.; Edmund James Mills, D.Sc.; Rev. Stephen Joseph Perry, F.R.A.S.; Dr. Henry Wyldbore Rumsey; Alfred R. C. Selwyn, F.G.S.; Major Charles William Wilson, R.E.

It is stated that Dr. J. H. Gladstone, F.R.S., has been nominated to succeed Dr. Odling at the Royal Institution.

The funeral of the late Professor Phillips will be solemnised at York to-day at 11 A.M. It is understood that this locality was fixed on by himself, other members of his family being buried there.

A deputation, consisting of Sir Bartle Frere, president of the Royal Geographical Society, Sir James Watson, Lord Provost of Glasgow, Sir William Stirling Maxwell, M.P., and several other members of Parliament, waited on Lord Derby last Friday, to lay before him the claims which exist for an official recognition of the late Dr. Livingstone's arduous services in the cause of humanity and of Science during his long tenure of office as one of Her Majesty's Consuls. The memorial, which was handed to Lord Derby, was signed by many eminent and well-known names, and his lordship said he agreed with the deputation that something ought to be done for the members of Livingstone's family. There seems no doubt that Government will meet the wishes of the country in this matter.

On Monday night, at the usual meeting of the Royal Geographical Society, the principal business of the evening consisted of reading extracts from the letters of Dr. Livingstone to Sir H. Rawlinson, to Sir R. I. Murchison, to Sir Bartle Frere, and to some private friends. This correspondence extended over six or seven years. Very voluminous materials have been preserved, but the work of editing them has yet to be performed. Sir Bartle Frere was happy to say that the son of the illustrious traveller accepted the duty of editing the materials left by his father, and had resigned a promising career in Egypt for that purpose.

The *Spectator* proposes that as an appropriate memorial to the late Dr. Livingstone, some Exploration Scholarships should be founded, to be called by the explorer's name.

Mr. F. J. Schuster has made a donation of 225*l.* to the Physical Laboratory of Owens College, Manchester, for the purpose of buying apparatus.

The Royal Irish Academy has sanctioned the following grants from the fund at its disposal for aiding scientific researches by providing suitable instruments and materials:—30*l.* to Messrs. Studdert and Caldwell for the chemical analysis of the mineral waters at Lisdoonvarna, in the county of Clare; 30*l.* to Prof. Macalister, to be expended in the purchase of rare insectivora and other mammals for dissection, in order to enable him to report on the myology of mammals; 40*l.* to Mr. W. H. Bailey, to investigate the fossils of the coal districts in Ireland, with a view to their comparison with those of British and other coal-fields; 50*l.* to Prof. Haughton, to complete an investigation into the chemical and mineral composition of the successive lava-flows of Vesuvius; 39*l.* 17*s.* 11*d.* (being the remainder of the fund) to Dr. David Moore, for the investigation and cataloguing of the Irish Hepaticæ. Gentlemen purposing to undertake scientific researches during the coming year, and desirous to obtain grants from this fund, are invited to send in their applications to the secretary of the Academy without delay.

The Ogham inscribed stones, ten in number, purchased by the Royal Irish Academy from the representatives of the late Mr. Windele, have been arranged in the crypt of their Museum with the other Ogham stones belonging to the Academy, one being set vertically in the floor, and the others placed either on iron stands in the bays at the south side, or on the dwarf walls forming the bays. These stones are now all easy of access, and, in the daytime, have the advantage of a light well adapted to the examination of their respective inscriptions. The Academy is in possession of 134 photographic negatives of Ogham inscriptions, representing about eighty different texts. It is intended to print these in autotype, and thus to afford to inquirers in this curious branch of study authentic copies of considerably more than half the whole number of such inscriptions known to exist. They will be accompanied by short notices, strictly limited to a statement respecting the localities where the inscriptions were found, and other matters of fact respecting them; the philological discussion and interpretation of them being left to the free competition of scholars.

Rear-Admiral Charles H. Davis was ordered, on Feb. 23, to the duty of superintendent of the Naval Observatory at Washington, U.S., in place of Rear-Admiral Sands, who has been detached and placed on the retired list, in accordance with the rules of the service. Admiral Sands, during his tenure of office, has merited the respect and goodwill of British Astronomers, who will view with regret the necessary termination of his functions.

Amongst the estimates passed by the House of Commons on Friday last was 80,000*l.* to continue the works on the New Natural History Museum at South Kensington, with which rapid progress is now being made.

In answer to a question in the House of Commons on Tuesday Viscount Sandon stated that arrangements consequent on the retirement of Mr. Cole were now the subject of consideration by the Science and Art Department, but had not yet been completed.

The Council of the Paris Observatory is said to have protested against a ministerial decision which allowed the Bureau des Longitudes to take the half of the astronomical library, which has been forming during centuries, and which is one of the richest in the world. It is almost certain that the decision will be cancelled, M. Leverrier having given the alternative of leaving the whole of the books in the hands of the Bureau, and refusing to be a party to such a mutilation. When the library shall be saved, it will be open to the public under certain regulations.

We recently announced the oppressive treatment to which M. Alglave, editor of *La Revue Scientifique* and Professor of Law at Douai, had been subjected; there is no doubt now that his suspension by the Minister of Public Instruction has been caused by his refusal to resign the editorship of the journal just mentioned and of the *Revue politique et littéraire*, of which he is also editor. On Monday week, on his going to open his class for the term, he received a letter from the Under-Secretary of the Education Department informing him that his course would be suspended until further notice. Science has many difficulties to contend with in this country, but happily vexatious interference on the part of the State is not one of them.

A paper on the grasses and fodder plants which may be beneficial to the squatter and agriculturist in South Australia, by Dr. Richard Schomburgk, director of the Adelaide Botanic Gardens, has been officially published by order of the Governor.

It is stated in the *Scientific American* that the well-known and much admired Japan lacquer-work, the secrets of which were supposed to be known only to the Easterns, has been successfully reproduced, or rather imitated, in Holland. The lacquer is prepared from Zanzibar copal, coloured black with Indian ink. The articles are painted with several coats of this lacquer, in which the pieces of mother-o'-pearl or other substances used for ornamentation are placed before it becomes hard. The lacquer is then dried by placing the articles in a heated oven or furnace, after which another coat of lacquer is applied, and when dry smoothed with pumice, which is repeated until all cracks are filled up and the surface has become perfectly smooth, when the whole is polished, or rather burnished, with tripoli.

THE Russian Scientific Expedition to the Amu Daria was to set out on Monday last. The expedition will be commanded by the Grand Duke Nicholas Constantinovitch, assisted by Colonel Stoletoff and Dr. Moreff, secretary. It will include 25 persons, whose work will be divided into four sections:—(1) The Trigonometrical and Topographical. (2) The Meteorological Section, which will construct two stations on the Amu Daria, at one of which hourly observations will be made of all the meteorological phenomena. (3) The Ethnographical Statistical Section. (4) The Natural History Section.

THE meeting of French Astronomers took place last week at the Ministry of Public Instruction, under the presidency of M. Leverrier. It was composed of M. Dumeril, director of the *Enseignement*, the astronomers from Paris, Toulouse, and Marseilles Observatories, and Officers from the General Staff of the Trigonometrical Survey. Four sittings were held, and an account of them will be issued shortly. Steps have been taken for the determination of the latitude of Algiers, by telegraph. M. du Barail, Minister of War, and M. Saget, his Staff-Officer, visited the Observatory last Saturday, in order to see for themselves how the work may be begun without further delay.

THE additions to the Zoological Society's Gardens during the last week include four Bladder-nosed Seals (*Cystophora cristata*) from Greenland, presented by Capt. Alex. Gray; a White-winged Whydah Bird (*Urobrachya albonotus*) from West Africa, presented by Mr. J. Fairchild; a Rose-crested Cockatoo (*Cacatua moluccensis*) from the Moluccas, presented by Mr. H. Baldwin; an Azara's Fox (*Canis azaræ*) from South America; a Snowy Owl (*Nyctea nivea*) from South America; a Green-cheeked Amazon (*Chrysotis viridigenalis*) from Columbia, purchased.

ON THE REFRACTION OF SOUND*

THE principal object of this paper is to show that sound, instead of proceeding along the ground, is lifted or refracted upwards by the atmosphere in direct proportion to the upward diminution of the temperature; and hence to explain several phenomena of sound, and particularly the results of Prof. Tyndall's recent observations off the South Foreland.

The paper commences with the explanation of the effect of wind upon sound, viz., that this effect is due to the lifting of the sound from the ground, and not to its destruction, as is generally supposed. The lifting of the sound is shown to be due to the different velocities with which the air moves at the ground and at an elevation above it. Owing to friction and obstructions the air moves slower below than above, therefore sound moving against the wind moves faster below than above, and the bottom of the sound waves will thus get in advance of the upper part, and the effect of this will be to refract or turn the sound upwards; so that the rays of sound which would otherwise move horizontally along the ground actually move upwards in circular or more hyperbolic paths, and may thus, if there is sufficient distance, pass over the observer's head. This explanation was propounded by Prof. Stokes in 1857, but it was discovered independently by the author.

The paper then contains descriptions of experiments made with a view to establish this explanation.

These experiments were made with an electric ball, over a nearly flat meadow, and again over the same when it was nearly covered with snow, and it was found (as indeed it was expected) that the condition of the surface very materially modified the results in two ways. In the first place, a smooth surface like snow obstructs the wind less than grass, hence over snow the wind has less effect in lifting the sound moving against it than over grass; and it is inferred that a still greater difference would be found to exist in the case of smooth water. In the second place, the ends of the waves of sound travelling along in contact with the rough ground are continually destroyed by the roughness, and the sound from above slowly diverges down to replace that which is destroyed, and this divergence gradually weakens the intensity of the lower parts of the waves, so that, under ordinary circumstances, the sounds which pass above us are more intense than those we hear. The general conclusions drawn from these experiments are:—

1. The velocity of wind over grass differs by ½ at elevations of 1 and 8 feet, and by somewhat less over snow.

2. That when there is no wind, sound proceeding over a rough surface is destroyed at that surface, and is thus less intense below than above; owing to this cause the same sound would be heard at more than double the distance over snow at which it could be heard over grass.

3. That sounds proceeding *with* the wind are brought down to the ground in such a manner as to counterbalance the effect of the rough surface (2), and hence, contrary to the experiments of Delaroche, the range of sound over rough ground is greater with the wind than at right angles to its direction or than when there is no wind. When the wind is very strong it would bring the sound down too fast in its own direction, and then the sound would be heard farthest in some direction inclined to that of the wind though not at right angles.

4. That sounds proceeding against the wind are lifted off the ground, and hence the range is diminished at low elevations. But that the sound is not destroyed and may be heard from positions sufficiently high (or if the source of sound be raised) with even greater distinctness than at the same distances with the wind.

5. In all cases where the sound was lifted there was evidence of diverging rays. Thus although on one occasion the full intensity was lost when standing up at 40 yards the sound could be faintly and discontinuously heard up to 70 yards. And on raising the head the sound did not at once strike the ear with its full intensity nor yet increase quite gradually; but by a series of steps and fluctuations in which the different notes of sound were variously represented, showing that the diverging sound proceeds in rays separated by rays of interference.

On one occasion it was found that with the wind sound could be heard at 360 yards from the bell at all elevations, whereas at right angles it could be only heard for 200 yards standing up, and not so far at the ground; and against the wind it was lost at 30 yards at the ground, at 70 yards standing up, and 160 yards at an elevation of 30 feet, although it could be distinctly heard at this latter point from a few feet higher.

It hence appears that these results agree so well with what might be expected from the theory as to place its truth and completeness beyond question.

The author then goes on to argue from the action of wind upon sound to another phenomenon which admits of a somewhat similar explanation. The effect of wind together with that of a rough surface in lifting the sound may be shown to account for many of the apparently capricious variations in the intensity with which sounds can be heard at different times; and it gives a reason for the custom which prevails of elevating church bells, platforms, &c., where the sounds are intended to be heard at a distance. But it does not explain a fact, which has often been observed, namely, that distant sounds can be heard much better during the night than during the day, and on dull cloudy days better than on bright hot days. This phenomena has engaged the attention of Humboldt, Delaroche, and recently of Prof. Tyndall, who have all assumed that the sound is obstructed or destroyed in the bright hot air, and have suggested causes which they thought might produce this effect. These suggestions are all more or less open to objection, and none of them meet the difficulty that any heterogeneous condition of the air which could obstruct sound must more or less refract or reflect light and so render vision indistinct. In this paper the author gives another explanation, in which he shows how, as in the case of wind, the sound may be lifted and not destroyed.

It is argued that since wind raised the sound simply by causing it to move faster below than above, any other cause which produces such a difference in velocity will lift the sound in the same way. And since the velocity of sound through air increases with the temperature—every degree from 32 to 70 adding 1 foot per second to the velocity—therefore an upward diminution in the temperature of the air must produce a similar effect to that of wind and lift the sound. Whereas Mr. Glaisher has shown by his balloon observations that such a diminution of temperature exists, and further he has shown that when the sun is shining with a clear sky the variation from the surface is 1° for every

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* On the Refraction of Sound by the Atmosphere. By Prof. Osborne Reynolds, Owens College, Manchester. Abstract of paper read before the Royal Society April 23.—Communicated by the Author.